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## **VARIABLE CURVATURE IN TAPE GUIDE ROLLERS**

### **RELATED APPLICATIONS**

5       The present invention is related to commonly  
assigned and co-pending U.S. Patent Application, Serial  
No. 10/746,383, Attorney Docket No. 2003-075-TAP,  
entitled "REDUCING TAPE MEDIA DAMAGE IN DATA REGIONS",  
filed on 12/26/03 and hereby incorporated by reference.

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### **BACKGROUND OF THE INVENTION**

#### **1. Field of the Invention:**

15       The present invention relates generally to  
mitigating tape media damage. More particularly, the  
present invention relates to an apparatus for restoring  
tape media to the center of a tape guide roller.

#### **2. Background of the Invention:**

20       Magnetic tape media, including reel and cassette-  
style cartridges and other devices that use magnetic  
media, are used in many industries to store data,  
programs, and other information. Magnetic tape media is  
typically stored on reels or spools, which are cylinders  
25       about which the tape media is wound, typically having  
flanges to guide the tape media onto the cylinder. The  
spools may be housed in a cassette or cartridge to  
protect the tape and increase the ease of handling.  
Accessing information from a reel or spool of tape media  
30       typically requires that the spool be inserted into a

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reading machine, which unwinds the tape media from the file spool, through a plurality of tape guide rollers and a read/write head and winds it onto a temporary storage spool (also referred to as a machine reel or machine  
5 spool) until the portion of the tape media with the desired information is reached. The temporary storage spool may either be external to the cassette (single reel) or integrated into the cassette (double reel). A magnetic read element reads the information, and, for the  
10 single reel cassette, the tape media is rewound back onto the original file spool and removed from the reader. For the double reel cassette, the tape is often parked halfway between the ends of the tape before being removed.

15 On a typical machine that is reading magnetic tape media, the tape guide rollers that control the tape media path have hard stops on each side of the roller. The spacing between the hard stops of the tape guide rollers is wider than the nominal width of the tape media. As  
20 the tape media is fed onto these tape guide rollers with hard stops, lateral tape media motion may occur during a start or stop operation, and edge damage may result. If the edge damage is severe, track following capability may be lost and the head to tape media spacing may increase  
25 to the point where data cannot be read back. In the most severe case the tape can break, leading to catastrophic failure.

As the thickness of tape media continues to get thinner, the tape media will be more prone to edge  
30 damage. A solution to lessen tape media damage would be

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to eliminate the occurrence of the tape media wearing against the hard stops of the tape guide roller. One such technique includes using tape guide rollers that are continuously curved and exerts a force to the tape media during a lateral shift, which returns the tape media to a properly aligned position, thereby minimizing the potential for tape media edge damage. However, due to the continuously curved roller, the tape media is under constant tension or compression, which can lead to edge damage.

Thus, it would be advantageous to have an apparatus for controlling the position of a magnetic tape media within a reading machine to mitigate tape media edge damage.

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### SUMMARY OF THE INVENTION

The present invention recognizes the disadvantages of the prior art and provides an apparatus for reducing tape media edge damage in data regions and controlling the position of the tape media in a passive manner. The apparatus of the present invention controls where edge damage may occur by returning the tape media to a properly aligned position by using tape guide rollers with curved edge stops that exert a force to the tape media during a lateral shift.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

10       **Figure 1** is a top view of a double reel tape cartridge in accordance with a preferred embodiment of the present invention;

15       **Figure 2** is a top view of a single reel tape cartridge in accordance with a preferred embodiment of the present invention;

**Figure 3** is a cross-sectional view of a known tape guide roller that uses hard stops to control the tape path;

20       **Figure 4** is a cross-sectional view of a tape guide roller showing the tape centered and experiencing substantially zero restoring force in accordance with a preferred embodiment of the present invention;

25       **Figure 5** is a cross-sectional view of a tape guide roller showing the tape offset and experiencing a restoring force in accordance with a preferred embodiment of the present invention;

30       **Figure 6** is a cross-sectional view of a tape guide roller showing varying amounts of possible curvatures in accordance with a preferred embodiment of the present invention;

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**Figures 7A and 7B** depict another embodiment of the present invention in which two tape guide rollers may be used in opposition to one another to control the path of the tape media; and

- 5        **Figures 8A and 8B** depict another embodiment of the present invention in which two tape guide rollers may be used in opposition to one another to control the path of the tape media, with one tape guide roller taking advantage of a hard stop.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

With reference now to **Figure 1**, a top view of a tape  
5 cartridge is depicted in accordance with the present  
invention. Tape cartridge **100** includes file reel **102** for  
supplying tape media to machine reel **104**. File reel **102**  
is also referred to as a supply reel. Machine reel **104**  
is also referred to as a take-up reel. Tape media **106**  
10 travels in a tape media path between file reel **102** and  
machine reel **104**. Alternatively, multiple read/write  
heads **108** may be used for reading and writing data to  
tape media **106**.

In this example, a plurality of tape guide rollers  
15 **112, 114, 116, 118, and 124** are provided for guiding tape  
media **106** through the tape media path, although any  
number of tape guide rollers may be used in the tape  
cartridge. Each tape guide roller **112, 114, 116, 118,**  
and **124** has a hollow core (not shown), which slides over  
20 a roller guide on the tape cartridge. The tape guide  
rollers may be flanged or unflanged, spinning or  
stationary, contoured or not contoured. Tape guide  
rollers **112, 114, 116, 118, and 124** limit lateral tape  
media motion, skew, and cross-web tension.

25 Post guides **120 and 122** may also be used to extend  
the total length of the tape media path. The inclusion  
of post guides **120 and 122** in tape cartridge **100** permits  
tape guide rollers **112, 114, 116, 118, and 124** to be  
moved as far as possible from file reel **102** and machine  
30 reel **104**. Any known guides may be used to implement post

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guides 120 and 122. Post guides 120 and 122 may be flanged or unflanged, spinning or stationary, contoured or not contoured.

Tape cartridge 100 is typically housed within a housing in a storage device. The housing, such as housing 110, is a finite size and a particular shape as determined by marketing requirements. The size and shape of the housing limits the placement of the various rollers, guides, heads, and reels of the tape mechanism.

Edge damage may occur in file reel 102 and machine reel 104. Edge damage may occur when the tape drive performs a start or stop operation. When the tape media is started again or is stopped, the tape media may experience some lateral motion as the tape media is brought up to speed or when the tape media is stopped. On a typical spool holding the magnetic tape media, the spacing between the upper and lower flexible flanges of the spools (both the file spool and the machine spool) is wider than the nominal width of the tape media. As the tape media is fed onto these spools, the tape media may move in a perpendicular to normal tape media motion during a start or stop operation, resulting in edge damage. This perpendicular movement is referred to as lateral tape motion. Tape media edge damage may be caused when the flexible flange is forced against the tape media during shipment or rough handling, since the edge of tape media is standing out from the tape pack. Tape media edge damage may also occur on the various rollers and guides such as tape guide rollers 112, 114, 116, 118, 120, 122, and 124. Tape damage occurs when



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these rollers and guides use a hard stop on either one or both ends. As the edge of the tape media is in contact with the hard stop, the edge may undergo damage from scraping along the edge. If the edge damage is severe,  
5 track following capability may be lost and the head to tape spacing may increase to the point where data cannot be read back.

The present invention may also be used with single reel cartridges, such as cartridge 200 as shown in **Figure**  
10 **2**. **Figure 2** illustrates a top view of a single reel tape cartridge in accordance with the present invention. Tape cartridge 200 includes file reel 202 for supplying tape media to a machine reel 218 located external to cartridge 200. Tape guide rollers 204, 206, 208 and 210 guide the  
15 tape onto and off of file reel 202. Tape guide rollers 212, 214 and 216 control the tape past the reader/writer 220 and onto the machine reel 218. Tape damage may occur in file reel 202 and machine reel 218 if the tape were to wear against the sides of the reels. Tape damage may  
20 also occur on tape guide rollers 204, 206, 208, 210, 212, 214, and 216 as tape media 222 travels in a tape media path between file reel 202 around tape guide rollers 204, 206, 208, 210, 212, 214, and 216 to machine reel 218.

**Figure 3** is a cross-sectional view of a known tape  
25 guide roller that uses hard stops to control the tape media path. Tape media 302 travels across tape guide roller 300 in an area of substantially zero curvature 304. During times when tape media 302 experiences lateral shift, the tape media 302 wears against hard stops 306,  
30 which prevents the tape media 302 from moving off the

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roller. However, there is no correction added to the tape media 302 to restore it to an optimal position, thus increasing the risk of edge damage as the tape wears against hard stops 306.

5       The present invention provides a method for preserving data integrity by reducing tape media edge damage in the tape data regions. Tape media is typically wound on one or two reels and around a plurality of tape guide rollers in a protective housing, such as a cassette  
10 or cartridge. Tape guide rollers act as guides for the tape media as the tape media winds to and from the reels and through read/write heads of a tape cartridge. As the tape media moves across the tape guide rollers, hard stops are provided at the edge of the tape guide rollers  
15 so that the tape media does not move off the tape guide roller. Tape media edge damage may be caused when the tape media wears against the hard stops. The present invention controls the tape media path as it moves with respect to the tape guide roller, such that the tape  
20 media is guided to a center portion of the tape guide roller, thus reducing tape media edge wear, preserving the integrity of the tape media and increasing the useful lifetime of the tape media.

Turning next to **Figure 4**, a diagram of a cross-  
25 sectional view of a tape guide roller showing the tape centered and experiencing substantially zero restoring force is depicted in accordance with a preferred embodiment of the present invention. Tape guide roller  
400 is shown having equal areas of positive curvature 404,  
30 and an area of substantially zero curvature 406. Tape

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media 402 travels across tape guide roller 400 in an optimal position being in the area of substantially zero curvature 406. As the tape travels across tape guide roller 400 in this optimal position the tape media 402 will experience substantially zero restoring force from the areas of positive curvature 404. The restoring force experienced by the tape media is related to the mechanical properties of the media. As tape media 402 moves laterally into an area of positive curvature 404, the tape media 402 must stretch if it is to stay in contact with tape guide roller 400. This elongation generates a strain in the tape media 402 and creates a restoring force to return the media to its original shape. This restoring force is proportional to the wrap angle of the tape media 402 around the tape guide roller 400. The larger the wrap angle, the larger the restoring force.

Turning now to **Figure 5**, a diagram of a cross-sectional view of a tape guide roller showing the tape offset and experiencing a restoring force is depicted in accordance with a preferred embodiment of the present invention. Tape guide roller 500 is shown having equal areas of positive curvature 504 and an area of substantially zero curvature 506. As an example, as the tape media 502 travels across tape guide roller 500 and experiences lateral shift, the tape media 502 enters an area of positive curvature 504. As the tape media 502 moves further up the positively curved portion of the tape guide roller 500, the slope increases which increases the restoring force 508 applied to the tape media 502. This restoring force 508 is exerted on the tape media 502 to

restore the tape media 502 to an optimal position in the area of substantially zero curvature 506. The restoring force 508 exerted on the tape media 502 as it moves into an area of positive curvature 504 arises from both the  
5 increased stress due to the curvature in the tape guide roller 500 as well as the wrap angle of the tape media on the roller.

**Figure 6** is a cross-sectional view of a tape guide roller showing varying amounts of possible curvatures in accordance with a preferred embodiment of the present  
10 invention. Tape guide roller 600 is shown having an area of negative curvature 602, an area of substantially zero curvature 604, and an area of positive curvature 606. When the tape media travels across the tape guide roller  
15 600 in the area of substantially zero curvature 604, substantially zero restoring force is present. When the tape media travels across the tape guide roller 600 in the area of positive curvature 606, a restoring force is present to move the tape media back to the area of  
20 substantially zero curvature 604. However, when the tape media moves onto the area of negative curvature 602, a negative restoring force will move the tape farther from the area of substantially zero curvature 604. This negative restoring force may be used to control the motion  
25 of the tape; however, if the tape media moves too far away from the area of substantially zero curvature 604, then the tape might come off tape guide roller 600 altogether. In accordance with the preferred embodiment of the present invention the tape guide roller has a tape guide  
30 surface with cylindrical symmetry. The cylindrical

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symmetry may be defined by a function, which may be one of a linear function and/or a nonlinear function.

Various functions may be considered in creating the curvature of the tape guide surface. Possible functions

5 may include without limitation exponential, brachistochrone, quadratic, cubic, or higher order simple polynomials.

In an alternate embodiment of the present invention, two tape guide rollers may be used in opposition to one  
10 another to minimize the tension waves that might arise from increased compression of the tape media as shown in a top view of **Figure 7A**. The tape media 700 may be threaded between two tape guide rollers where the curvature can be in opposition as with tape guide rollers 702 and 706. In  
15 this embodiment, if tape media 700 were to experience a lateral shift into the area of positive curvature 704, tape guide roller 706 would provide the restoring force necessary to move the tape back to an area of substantially zero curvature 710. If an alternate lateral  
20 shift were to occur, moving tape media 700 into the area of positive curvature 708, then tape guide roller 706 would provide the restoring force necessary to move the tape back to an area of substantially zero curvature 710. **Figure 7B** provides a side view of the alternate embodiment  
25 of **Figure 7A**.

In still another alternate embodiment of the present invention, two tape guide rollers may be used in opposition to one another to minimize the tension waves that might arise from increased compression of the tape  
30 media with one tape guide roller taking advantage of a

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hard stop, as shown in **Figure 8A**. The tape media 800 can be threaded between two tape guide rollers where the curvature can be in opposition as with tape guide rollers 802 and 806. In this embodiment, if tape media 800 were to experience a lateral shift into the area of positive curvature 804, tape guide roller 806 would provide the restoring force necessary to move the tape back to an area of substantially zero curvature 810. In addition, if the lateral shift experienced by tape media 800 was an extreme shift, then hard stop 812 would prevent tape media 800 from experiencing and further lateral shift. If an alternate lateral shift were to occur, moving tape media 800 into the area of positive curvature 808, then tape guide roller 806 would provide the restoring force necessary to move the tape back to an area of substantially zero curvature 810. **Figure 8B** provides a side view of the alternate embodiment of **Figure 8A**.

Thus, the present invention solves the problems associated with the prior art by providing an apparatus for reducing tape media edge damage. The apparatus of the present invention reduces tape media edge damage on tape media by restoring the tape media to an optimal position on the tape guide roller, which is aligned with the read/write head, machine reel, and/or file reel. Although tape media edge damage may occur, the present invention controls the position of the tape media, such that tape media edge damage is reduced, degradation to tape media integrity is reduced and useful lifetime of the tape media is expanded. As a result, data integrity may be preserved. In addition, the rollers act to

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control the tape media path in a passive manner by returning the media to the substantially zero curvature part of the tape guide roller.

5 The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in  
10 order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.